THE SPREAD AND INCIDENCE OF INTESTINAL PROTOZOAL INFECTIONS IN THE POPULATION OF GREAT BRITAIN

III. CHILDREN

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In a previous paper (1919) we directed attention to the fact that intestinal protozoal infections were frequent among the younger persons we examined in Liverpool Royal Infirmary. To obtain further data on this point we decided to examine the stools of children. Material for the investigation was obtained at the Liverpool Infirmary for Children, where all the patients are under 12 years of age. The cases examined were in hospital for various diseases, the great majority being non-intestinal. A small number admitted with summer diarrhoea will be considered later. The protozoal findings, based on a single examination per case, are given in Table I.

TABLE I.

Showing percentage of cases infected with intestinal protozoa.

	Number examined	*E. histolytica*	*E. coli*	*E. nana*	*Giardia intestinalis*	*Chilomastix mesnili*
Boys... ...	321	1·9	10·3	3·4	14·6	0·3
Girls ...	227	1·8	12·3	1·8	13·2	4·0
Total ...	548	1·8	11·1	2·7	14·1	1·8

The following Helminthic infections were found:—

Trichuris trichiura ... in 3 cases
Oxyuris vermicularis in 3 cases
Taenia saginata ... in 2 cases
Hymenolepis nana ... in 1 case

Iodine cysts were found in one case.

The total number of cases examined is probably large enough to give a fairly reliable idea of the incidence of protozoal infections among children in Liverpool.

Giardia intestinalis appears to be the commonest protozoon, although in our records for adults *E. coli* has always been the most prevalent. Arrangement of the cases according to sex gives somewhat small and rather unequal numbers in the two groups, nevertheless the figures in Table I indicate that infections are equally common among boys and girls.

The number of children examined at different ages and the infections discovered in each age group are shown in Table II.

Table II.

Age in years	Number of cases examined	*E. hist.* cases	*E. coli* cases	*E. nana* cases	*G. int.* cases	*C. mesnili* cases
0–1	50	...	...	...	...	...
1–2	79	...	4	...	6	1
2–3	74	1	9	2	18	1
3–4	56	2	12	1	9	2
4–5	66	...	10	2	12	2
5–6	43	1	5	1	5	...
6–7	44	2	6	2	10	1
7–8	36	1	5	3	4	1
8–9	42	...	4	2	5	1
9–10	27	...	2	...	4	...
10–11	23	2	4	2	3	1
11–12	8	1	...	...	1	...

Among fifty children, under one year of age, no infections were found. Children in their second year, however, were discovered to be infected. *Giardia* and *Chilomastix* were detected in a girl of one year and two months, while a boy of one year and four months was infected with *E. coli* and *Giardia*. *E. histolytica* and *E. nana* were discovered in a girl just three years of age. It appears then

that children may become infected with intestinal protozoa soon after they are twelve months old.

The numbers in the age groups shown in Table II are too small to allow of generalisations from the results. We have therefore arranged in two groups all the cases that were over one year of age (Table III). Since there is no evidence that children under one year are infected, the fifty cases coming within this category have been excluded.

Table III.

Children 1–5 years of age.		Children 5–12 years of age	
Number examined	275	Number examined	223
E. histolytica...	1·1	*E. histolytica*...	3·1
E. coli	12·7	*E. coli*	11·6
E. nana	1·8	*E. nana*	4·5
G. intestinalis	16·4	*G. intestinalis*	14·3
C. mesnili	2·2	*C. mesnili*	1·8

It will be seen from Table III that the common protozoa *E. coli* and *G. intestinalis* are equally prevalent in the two groups. The number of cases infected with *E. histolytica*, *E. nana* and *C. mesnili* respectively is, however, too small to justify any close comparison. The chief interest of the results lies in the fact that all the common intestinal protozoa of man are to be found in children not exceeding five years of age.

It is of interest, therefore, to compare the general results for children with those obtained for other sections of the population examined. Comparative figures are given in Table IV.

The children in the Liverpool Infirmary for Children and the adults in the Royal Infirmary constitute, so far as we know, very similar samples of the general population, the only outstanding difference between the two groups being age. It seems admissible, therefore, to make a fairly close comparison of the results obtained for the two series. Among children the commonest protozoon is

G. intestinalis and if we exclude the fifty cases who were under one year of age, the percentage of infection with this flagellate becomes 15·5.* On the other hand, only 6 per cent. of the adult population as seen in the Royal Infirmary sample were infected with *G. intestinalis*. Table IV also shows that among army recruits of 18 years of age, the flagellate was found in only 7 per cent. We think there must be some reason for the decidedly greater prevalence of *G. intestinalis* among children compared with adults. In our previous paper we

TABLE IV.

Showing percentage of cases infected with intestinal protozoa among Children, Adults and Army Recruits never out of Britain.

	Children	Adults	Army Recruits
No. examined	548	450	1098
E. histolytica	1·8	1·5	5·6
E. coli	11·1	6·7	18·2
E. nana	2·7	2·4	5·5
G. intestinalis	14·1	6·0	7·0
C. mesnili	1·8	1·5	2 cases

made the suggestion that intestinal protozoa may disappear from the intestine in the course of time, and it seems that *G. intestinalis* may be a case in point. It may be that the flagellate is mainly a parasite of children and becomes rarer in older people.

In the case of adults the chances of becoming infected are probably greatly reduced on account of their usually greater cleanliness. The chance of adults becoming infected must, however, by no means be entirely excluded. Nevertheless, instead of the percentage of *G. intestinalis* infection in adults being greater or even the same as in children it is very much less, and we can offer no explanation of this remarkable fact other than that already advanced.

* In discussing the incidence of infection among children we think it important to remember that liability to infection does not appear to occur until the child has entered his second year (see Table II). If any series of children happened to contain a large number under one year of age it is clear that the results would be correspondingly low.

The number of cases infected with the flagellate—*C. mesnili*—is too small to warrant any discussion of the results. This is true also of the amoebic infections with the exception of *E. coli*. This amoeba is not so prevalent among children as among recruits, although it appears commoner in the children than in the adult section of the population. It is possible that *E. coli* infections are also lost in the course of time. The figures in Table IV support this suggestion.

It is necessary to point out in connection with the foregoing remarks on the probable loss of infections that the evidence at our disposal is indirect. Before the question can be finally determined it will be necessary to examine given infected cases for prolonged periods, and it seems that this would now form a promising line of enquiry regarding the behaviour of the intestinal protozoa of man. We would also mention that the parasites in all probability do not behave alike. On this point, however, we have no evidence.

Before proceeding to give histories of some of the cases infected with *E. histolytica* we may mention that thirty-two of the children examined were admitted to hospital suffering from summer diarrhoea. Of these, seventeen were under one year of age and were negative. Among the remaining fifteen, three infections with *E. coli* were found. There is no evidence, therefore, from this small number of cases, that intestinal protozoa are in any way connected with the occurrence of summer diarrhoea in children.

In order to obtain a closer insight into the actual process of spread of these protozoal infections we have singled out certain cases, chiefly those infected with *E. histolytica*, and have examined the whole family of which each one was a member. In only one family were we able to examine the parents as well as the children and the records in this case (Family I) proved of great interest. In all the other families we examined the children only. Table V gives the results.

It is of great importance to keep clearly in mind that these are the results of one examination only.* They are therefore minimum results. At least the infections recorded were present, probably, in fact almost certainly, others also.

* The child, however, who was the starting point of the investigation in each family, was examined twice.

Table V.

Family	Case	Age	Protozoa present					Non-protozoal Infections	
			E. b.	*E. c.*	*E. n.*	*G. i.*	*Ch. m.*	I. cysts	Hymenolepis eggs
I.	J. S.	41	+	...	+	...	...	...	...
	L. S.	41	+	+	+	...	...	...	...
	L. S.	16	+	+	+	...	...	...	...
	F. S.	13	+	+	+	...	...	...	...
	Ja. S.	11	+	+	+	...	...	...	...
	J. S.	9	...	+	...	...	+	...	+
	M. S.	7	+	+	+	+	...	...	...
	D. S.*	3	+	...	+	+	...	...	...
II.	E. P.	13	+	+	+	+	...	...	...
	S. P.*	11	+	+	...	...	+	...	...
	E. P.	9	+	+	+	...	...	...	...
	J. P.	5	+	...	+	+	...	...	+
III.	M. C.*	7	+	+	...	...	+	+	...
	C.	5	+	+	...	...	+	+	...
	C.	3	...	+	...	+	...	...	...
	C.	5/12	...	...	...	...	...	...	...
IV.†	W. H.	10	...	+	...	...	...	...	...
	E. H.*	6	+	...	...	...	...	...	...
	W. C.	7	...	...	...	...	...	...	...
V.	J. W.*	7	+	+	+	...	...	...	...
	H. W.	4	+	...	+	...	...	...	...
	F. W.	1½	...	+	...	+	...	...	...
VI.†	H. M.*	11	+	+	...	...	...	...	...
	A. J.	5	...	+	+	...	...	...	+
	L. J.	3	...	...	...	...	...	...	...
VII.	G. T.	6	...	+	+	...	+	...	...
	E. T.*	3½	...	+	+	+	+	...	...

* The original case in the Children's Infirmary.

† Two related families occupied the same house.

It is clear from Table V that within certain families infections are much more common than in the general population of children. This is strikingly seen in Family I, where, in one family only, there are almost as many *E. histolytica* infections as we have found in the 548 cases taken from single members of different families. This applies also to the other infections particularly to *E. coli* and *E. nana*.

There are at least two possible ways in which this state of affairs may have been brought about. (1) A single member (or some small number of members) of the family has become infected in a way at present unknown and from this source the infection has spread to the other members of the family. Intercourse between members of the same family is close and long-continued and therefore many more chances of infection must occur within the limits of the family than beyond them. It is therefore not surprising that, once there is a source of infection within the family, the infection should spread throughout the family. (2) The whole family or those members of it who have similar infections may have been infected simultaneously, for instance by all eating food from the same contaminated source. In this case there would be no subsequent spread within the family. We think the former method the more probable, for if whole families or considerable proportions of them can be simultaneously infected from an outside source, it would be expected that the general population of children would show a considerably higher proportion of infections than is actually the case. Bacterial infections such as those spread by contaminated food or water spread rapidly through the population and may even result in epidemics. In the case of intestinal protozoal infections it seems that such families as have here been investigated form, as it were, isolated pockets among a general population fairly free from infection. This is particularly true of *E. histolytica*, the only one of these infections known to be pathogenic.

With regard to the possibility of the fly being a carrier of protozoal infections we can only say that, though most of the families belonged to the poorest section of the population, all the houses we investigated were provided with water-closets and therefore, as a general rule, faeces were not exposed. On the assumption that the infections spread somewhat slowly within the family the fly probably does not play a prominent part as a carrier. Infection however must

occasionally be carried across the limits of a family and the fly may be the agent in this. Exposed faeces do, no doubt, occasionally occur in and about such homes and flies may become the agents which spread the infections among the general population.

With regard to the possible source of these protozoal infections it may be recorded that in each of the families investigated, one member—in six of the families the father, in the seventh a brother—had been abroad and had visited the home after going abroad. In five cases this member of the family was a soldier and in two cases a sailor. It is therefore possible that all the infections had their origin abroad. It is not at all necessary to make this supposition however, for protozoal infections, as we have shown (Matthews and Smith (1919)) are sufficiently common in all sections of the population to warrant the belief that they may have existed in this country before the war.

On the supposition that races producing cysts of definite average size exist in *E. histolytica* and *E. coli* (see Wenyon and O'Connor (1917), Dobell and Jepps (1918), Smith (1918), Matthews (1919)), we thought it worth while to make measurements of the size of the cysts in those infections in which the cysts were present in sufficient numbers. We thought that if the members of the family were all infected from one source they would probably pass cysts of the same average size. The results are given in Table VI.

Table VI.

Family	Case	Age	Protozoon	Average diameter of 50 cysts measured (μ)
II.	E. P.	13	*E. histolytica*	12·9
	J. P.	5	*E. histolytica*	12·8
I.	J. S.	9	*E. coli*	16·5
	Ja. S.	11	*E. coli*	16·4
	L. S.	16	*E. coli*	16·8
	M. S.	7	*E. coli*	18·3

The evidence does not go far, but such as it is, it points to one race, and therefore presumably one source of infection, for the *E. histolytica* infection in the two members examined of Family II, and to two sources of infection in the four members of Family I.

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SUMMARY

1. Stools were examined for intestinal protozoa from 548 children under 12 years of age. *E. histolytica* was found in 1·8 per cent. and the commonest protozoon was *G. intestinalis*, found in 14 per cent.

2. Children become infected soon after they are one year old and from this age onward all the common intestinal protozoa are found, irrespective of age or sex.

3. The results have been compared with those from a similar population of adults and it has been observed that *G. intestinalis* in particular is much more common among children.

4. Investigation of whole families of which one member was known to be infected showed that in certain families infections were much more common than in the general population.

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